

Before the introduction of the absolute system of electro-magnetic measure, there was no means of estimating the electromotive force so brought into play by the flow of a river or ocean stream, and the magnitude of the effect was perhaps overestimated.

A Table is given, showing the electromotive force in volts produced in two or three cases.

	Difference of potential between two sides in volts.
Gulf-stream at lat. 30° N., long. 60° W.	8·6
Equatorial current, lat. 10° N., long. 40° W. ..	10·0
Dover and Calais tidal current	3·0
Thames at Waterloo Bridge	·016

This electromotive force without doubt generates a current transverse to the direction of the flow; but since the surrounding still water or the river bed or channel is not a non-conductor, any attempt practically to detect it by plates placed on either side of the stream is not likely to succeed, since the current through the galvanometer is only a derived portion of the current in the stream.

A comparison of a chart of ocean-currents with one of the isogonic lines does not seem to show any distortion of the lines of equal variation where they cut across. If, now, electric currents of any great magnitude were generated in ocean-currents, such would undoubtedly be the case. Though Faraday's failure to detect any magneto-electric current in the Thames may have been partly due to his employment of polarizable electrodes, still there is evidence enough to show that these currents, though certainly existing and capable of being produced on a laboratory scale, cannot be regarded as contributing in any sensible degree towards affecting the form and distribution of the isogonic lines. Those who have looked to this as a possible partial cause of the irregularity observed have been led, no doubt, by the dimensions of the streams to exaggerate the magneto-electric induction caused by their flow.

II. "On the Structure and Development of Vascular Dentine."

By CHARLES S. TOMES, M.A. Communicated by JOHN TOMES, F.R.S. Received February 6, 1877.

(Abstract.)

The nomenclature and classification of the varieties of dentine have hitherto been based solely upon the appearances discoverable in dried teeth; in the present communication the author seeks to amend and place upon a more satisfactory basis the grouping of these several kinds of dentine, by bringing to bear upon their arrangement observations upon the nature of the contents of those large tubes which give to the tissues their name of "vascular" dentine, and, more especially, observations upon the methods by which they are developed.

VASO-DENTINE is the term generally used to designate a variety of dentine exceedingly common in the class of Fish, in which the substance of the tooth is permeated by a number of anastomosing tubes, of considerable size, which have been called "medullary" canals, as they have been supposed to contain pulp-tissue; whilst OSTEO-DENTINE is used to designate that variety of vaso-dentine in which the matrix is arranged in concentric layers round the canals, like the laminæ of an Haversian system in bone, and in which spaces like the lacunæ of bone occur.

The author would not propose to introduce any new terms, but to render more precise and definite the meaning attached to the terms vaso-dentine and osteo-dentine, premising that the application of the two words will be greatly altered by so doing.

The author defines VASO-DENTINE as a modification of dentine which is permeated by a system of canals far larger than ordinary dentinal tubes, which anastomose freely with one another, and contain capillary blood-vessels and nothing else. That is to say, each several canal contains a capillary of the same calibre as itself, and no cellular or other pulp-tissue, for which, in fact, there is no room; the canals were formed by the enclosure of capillaries of the pulp in a calcified matrix. True dentinal tubes may coexist with the large capillary canals; but if they do, they radiate from the central pulp-chamber and not from the canals: in the most typical vaso-dentine, such as that of the hake, the matrix is solid and there are no true dentinal tubes. Vaso-dentine is developed from a sharply defined "*membrana eboris*," or layer of odontoblast cells.

OSTEO-DENTINE, on the other hand, is also permeated by a system of large channels, but these do not (except as an accident) contain capillary blood-vessels, nor were they developed around capillaries. True "dentinal tubes" can perhaps hardly be said to exist; but the tubes of small calibre which do exist radiate, not from a common pulp-chamber, but from the several canals.

Its greatest distinction from vaso-dentine lies in the manner of its development. It is not (if we except a thin outer layer of hard dentine with which it is often clothed) developed from a specialized layer of odontoblast cells; but calcifying trabeculæ shoot rapidly from the interior of the first-formed dentine cap through the whole substance of the formative pulp, and the canal-system ultimately formed is due to the partial coalescence of these ossifying trabeculæ leaving interspaces between them. The canals have therefore nothing whatever to do with the blood-vessels of the pulp, and therefore do not correspond very closely with those of vaso-dentine. Osteo-dentine is thus not derived from the calcification of a "*membrana eboris*," or special layer of odontoblast cells, but by ossification (of cells like osteoblasts) shooting through its whole mass.

Thus the tooth-pulp can be bodily withdrawn from a tooth consisting of vaso-dentine by tearing across the capillaries only, and the interior of the dentine cap will be left smooth; but the pulp can by no possibility

be withdrawn from a tooth which is advancing in calcification into osteo-dentine, because it is permeated through and through by a network of calcifying trabeculæ.

It is possible by careful observation to distinguish in sections of dried teeth true vaso-dentine from osteo-dentine ; the majority of teeth consisting of the latter tissue ordinarily pass as consisting of the former (*e. g.* the teeth of the pike, of many Plagiostomi, which really consist of osteo-dentine, but are always described as vaso-dentine).

The teeth of the hake are selected as an illustration of vaso-dentine ; they have large pulps, richly vascular, and red blood circulates abundantly through the capillary channels of the dentine, so that the tooth, when the fish is alive, is brilliantly red.

The matrix of the dentine is dense and solid ; *i. e.* it is not permeated by dentinal tubes.

The transition between typical vaso-dentine, such as that of the Gadidæ, and hard unvascular dentine, such as that of most mammalian teeth, is gradual.

Thus most of the Pleuronectidæ have teeth which at their basal halves consist of typical vaso-dentine without dentinal tubes, just like that of the Gadidæ ; but above the middle, dentinal tubes radiating out from the central pulp-chamber begin to appear, at first sparsely, and the capillary canals to become fewer, till the apex of the tooth consists of ordinary fine-tubed dentine, in which few, if any, capillary channels exist.

And in *Serrasalmo* there are teeth which are throughout composed of a dentine permeated by dentinal tubes, but in the basal half of the tooth a few capillary channels are present. From such a form of dentine to ordinary hard unvascular dentine is but a short step.

The development of osteo-dentine is illustrated by a description of the teeth of a pike ; the outer layer is developed, like dentine, from a layer of cells analogous to, though less specialized than, odontoblasts ; and so soon as this has been calcified the interior of the tooth is formed by a rapid ossification, just as the subjacent bone is formed.

Vaso-dentine therefore differs much less from true or unvascular dentine than osteo-dentine does, the relation between the three tissues being well seen in the teeth of Sparidæ.

In *Sargus ovis* the incisor-like front teeth appear to be implanted by long roots ; these are formed by the dentinal formative pulps, just as are the roots of ordinary rooted teeth.

But there is this peculiarity in the nature of the process : the dentinal pulp, so long as the "crown" (or portion which will be above the bone) is being developed, is converted into fine-tubed *unvascular dentine* ; but so soon as the root or implanted portion commences to be formed, this same dentinal pulp, the apex of which is even yet forming unvascular dentine, calcifies into *vaso-dentine*. Without there being any exact break or breach of continuity, the change from true dentine to vaso-

dentine is sudden, and the tooth is easily broken off at this point. When the greater part of the length of the root has been formed the manner of calcification again changes, this time not so abruptly, till near to the end of the root the dentinal pulp becomes converted into *osteo-dentine*, which is quite indistinguishable from and blends insensibly with the surrounding coarse bone by which the tooth is fastened into the socket; there is, in fact, no reason for calling it any thing else than coarse bone, except the fact that it is the product of calcification of a dentinal pulp. In this case a single dentinal pulp forms first hard dentine, secondly vaso-dentine, and at last osteo-dentine.

Another variety of complex dentine is brought about by foldings and subdivisions of the formative pulp: both vaso-dentine and osteo-dentine are formed by the calcification of simple pulps; but in many instances the odontoblast-bearing surface of the pulp is itself complicated in form, and a dentine arranged as it were round many pulp-chambers is the result.

For this no better name than *PLICI-DENTINE* (also a term already in use) suggests itself: it is to be seen in its simpler form at the base of the teeth of *Lepidosteus*, in greater complexity at the base of the teeth of *Varanus*, and in exceeding complexity in the teeth of Labyrinthodonts.

The author would distinguish, therefore:—

- (i) *Hard unvascular dentine*, the characters of which are sufficiently known.
- (ii) *Vaso-dentine*, which is developed from odontoblasts after the manner of dentine, but contains an anastomosing network of canals modelled around and containing capillaries.
- (iii) *Plici-dentine*, developed from odontoblasts, but from a complicated pulp, so that it is more or less divided up into distinct systems of dentinal tubes.
- (iv) *Osteo-dentine*, developed from osteoblasts, like bone, and quite unlike dentine; permeated by a system of large canals, which do not contain, or have any special relation to, blood-vessels.

The author lays no stress on the characters formerly given as distinctive of osteo-dentine (*i. e.* a laminated arrangement of the matrix and the presence of lacunæ), because (i) lamination of the matrix is not unknown in vaso-dentine, (ii) lacunæ are very frequently absent from bone in fishes, and very frequently from osteo-dentine, so that these characters, as those who have tried to apply them have found, are not useful in practice.

The attachment of the teeth of the hake is so peculiar as to merit a word of notice: the inner and longer of the two rows of teeth are set upon elastic hinges, which allow of their being bent inwards towards the throat, but cause them at once to spring back into the upright position when pressure is taken off them. This arrangement, shared by the angler, was hardly to be expected in one of the Gadidæ; but the author has found in

others of the family steps towards this highly specialized arrangement, the benefit of which to a voracious predatory fish, such as the hake, is obvious*.

The common cod has teeth which admit of a small amount of motion only; but a comparison of them with those of the hake shows clearly that a further modification in the same direction would lead to an attachment similar to that of the latter fish.

The haddock, which in this respect is a fair representative of the family, has teeth which admit of no motion at all.

III. "Note on the Early Stages of Development of the Nerves in the Chick." By A. MILNES MARSHALL, B.A., B.Sc., of St. John's College, Cambridge. Communicated by Dr. MICHAEL FOSTER, F.R.S., Prelector of Physiology in Trinity College, Cambridge. Received February 13, 1877.

In the investigations here described embryos of ages from thirty-six hours to four days were employed. These were, for the most part, hardened by immersion in picric acid, prepared after Kleinenberg's method, for three to five hours, and then in alcohol of gradually increasing strength. It is to the use of picric acid as a hardening agent that the results obtained are believed to be in large measure due. All the more important results have, however, been confirmed by specimens hardened in chromic acid in the usual manner, though such specimens have almost invariably proved inferior in distinctness to those prepared with picric acid. Good results have also been obtained from duck-embryos hardened in picric acid.

Owing to the less compact character of the mesoblast of the head and to the absence of protovertebræ, the development of the cranial nerves is easier to study than that of the spinal, and will therefore be considered first.

Transverse sections through the hind brain of a forty-three hours' chick show that the cells along the median dorsal line are more spherical in shape and slightly smaller than those composing the rest of the brain; also that these spherical cells grow upwards, so as to form a conspicuous longitudinal ridge running along the upper surface of the hind brain immediately beneath the external epiblast.

This ridge is traceable along the whole length of the hind brain, but is much more prominent posteriorly than it is in front, where it gradually disappears. At intervals the ridge becomes more prominent, and grows

* Since the accompanying paper was placed in the hands of the Royal Society, the author has found that the vomerine and palatine teeth of the pike present a similar hinged manner of attachment, so that they oppose no obstacle to the swallowing of prey seized by the fish.